Spallation Neutron Source
Personnel Protection System

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PPS Highlights

- Modeled after systems installed at CEBAF and APS
- Executed in accordance with the requirements contained in the the ANSI/ ISA standard S84.01
- Provides protection against prompt radiation from accelerator operations
- Based on SNS standard programmable logic controllers
- Divided into segments to facilitate maintenance and testing

Overview


Entrance Door
Emergency Exit Door
Linac
Injection Dump
Ring
PPS Gate
Shield Wall
PPS Gate
PPS Gate
Entrance Door
Entrance Door
RTBT
Entrance Door
Beam Lines (typ.)
HEBT
Utility Vault
Control Room

PPS Safety Functions

- Prevent beam operation in segments not cleared of personnel (beam containment)
- Prevent rf klystron operation and energizing of exposed electrical conductors in segments not cleared of personnel
- Shut off beam if personnel enter an operating segment
- Shut off rf klystrons and de-energize exposed electrical conductors if personnel enter an operating segment

PPS Safety Functions

- Shut off beam if equipment faults cause radiation levels to increase over normal levels
- Support administrative actions to clear personnel from segments before beam operation
- Warn personnel located in segments before beam operation

Critical Devices

- Beam Cutoff
  - -65 KV High Voltage for the Ion Source
  - RF to the RFQ
- Beam Containment
  - Dipole magnets in the HEBT
  - Lambertson Dipole
  - RTBT dipole magnet DH13

Controlled Devices

- -65 KV High voltage power supply
  - Redundantly controlled by 480 VAC PPS contactors
- RF Klystrons
  - Redundantly controlled by:
    - Interlock on 2100 VAC circuit breaker for high voltage modulator
    - RF transmitter interface

Controlled Devices

- HEBT and Lambertson dipole magnet power supplies
  - Redundantly controlled by:
    - 480 VAC PPS contactors
    - Power supply interfaces
- Other magnet power supplies
  - Power supply interface

    or
  - Common AC contactor for multiple small power supplies
- RTBT dipole magnet DH13 power supply
  - AC & DC disconnects provided by Target Protection System with an interface to PPS for status

PPS Operating Modes

Mode	Features
Restricted Access	Personnel access to segment controlled by operator, radiation work permit badge reader, or both. Hazardous operations in segment not permitted.
Search	Personnel access to segment controlled by operator. Only search personnel allowed in segment. Hazardous operations in segment not permitted.
Controlled Access	Personnel access to segment controlled by operator. Access limited to trained personnel. Personnel will be required to carry an exchange key while in the segment. Hazardous operations in segment not permitted.

PPS Operating Modes

Mode	Features
Controlled Access—Magnets Energized	Personnel access to segment controlled by operator. Access limited to trained personnel. Personnel will be required to carry an exchange key while in the segment. Exposed energized conductors may be energized. Rf or beam operations in segment not permitted.
Power Permit	No personnel access permitted. Rf klystron operation, energized exposed conductors allowed. No beam operation in segment.
Beam Permit	No personnel access permitted. Full operation allowed.

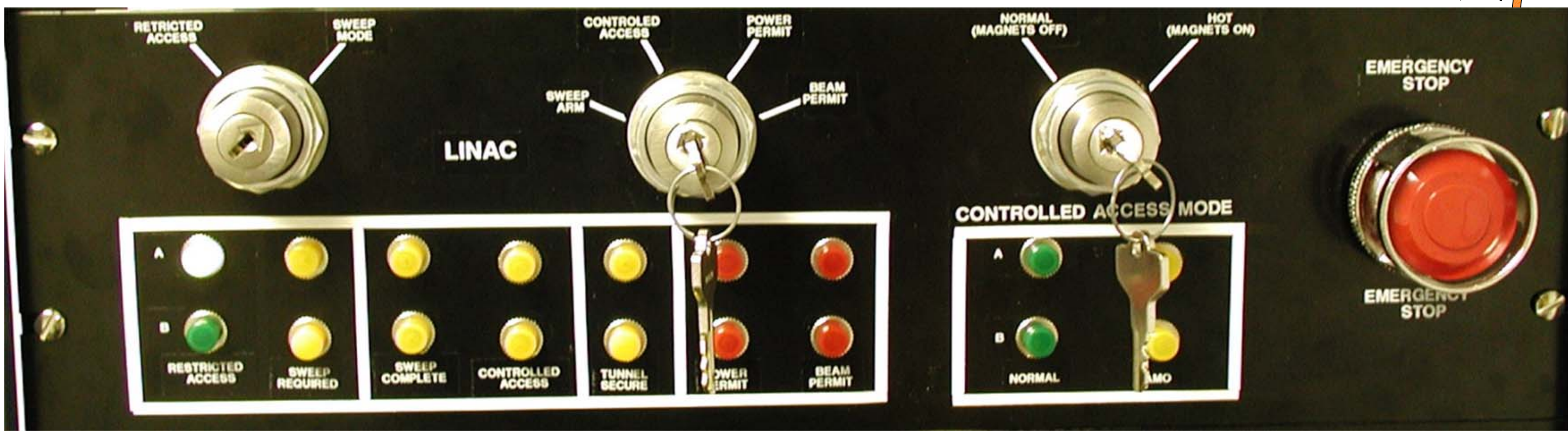
PPS Beam Containment Modes

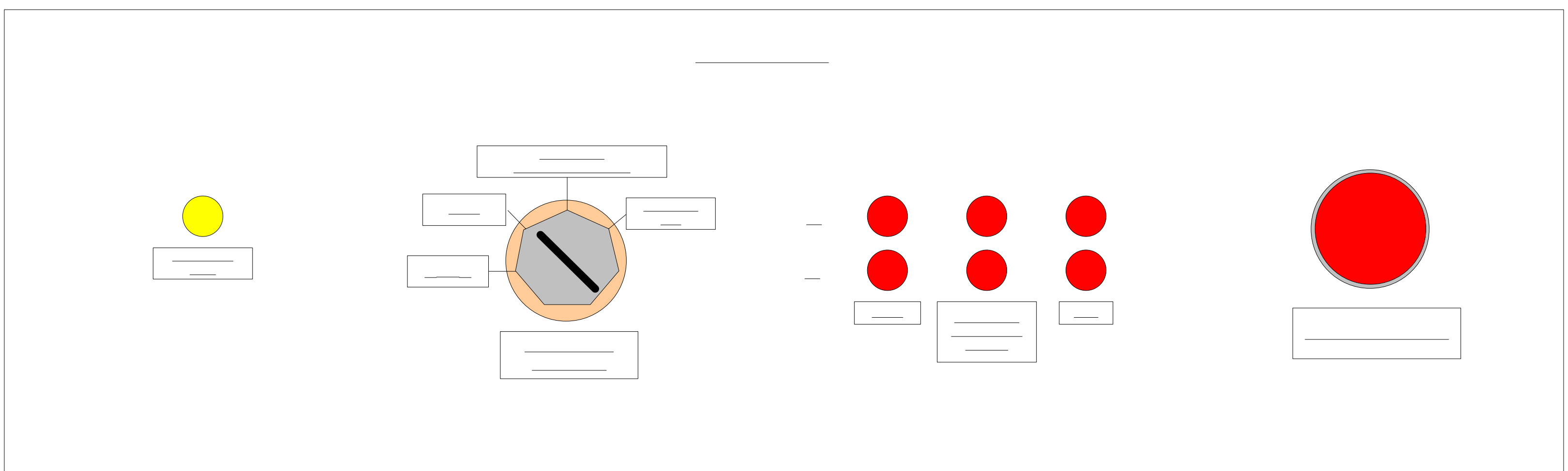
Mode	Operating Equipment	Beam Containment Mechanisms
Ion Source Conditioning	Ion Source	RF to RFQ 65 KV or Plasma RF supply
LINAC Tuning	Front End, LINAC, and LINAC Dump	First Dipole Magnet in HEBT Second through Seventh Dipole Magnets in HEBT
Ring Tuning	Front End, LINAC, LINAC Dump, Ring, RTBT, Injection and Extraction Dump	RTBT Dipole Magnet (RTBT.DH13) Lambertson Dipole

PPS Beam Containment Modes

Mode	Operating Equipment	Beam Containment Mechanisms
Full Operation	Front End, LINAC, LINAC Dump, Ring, RTBT, Injection and Extraction Dump, Target and Beam Lines	Mercury Target Beam Line Shutters

Operator Controls





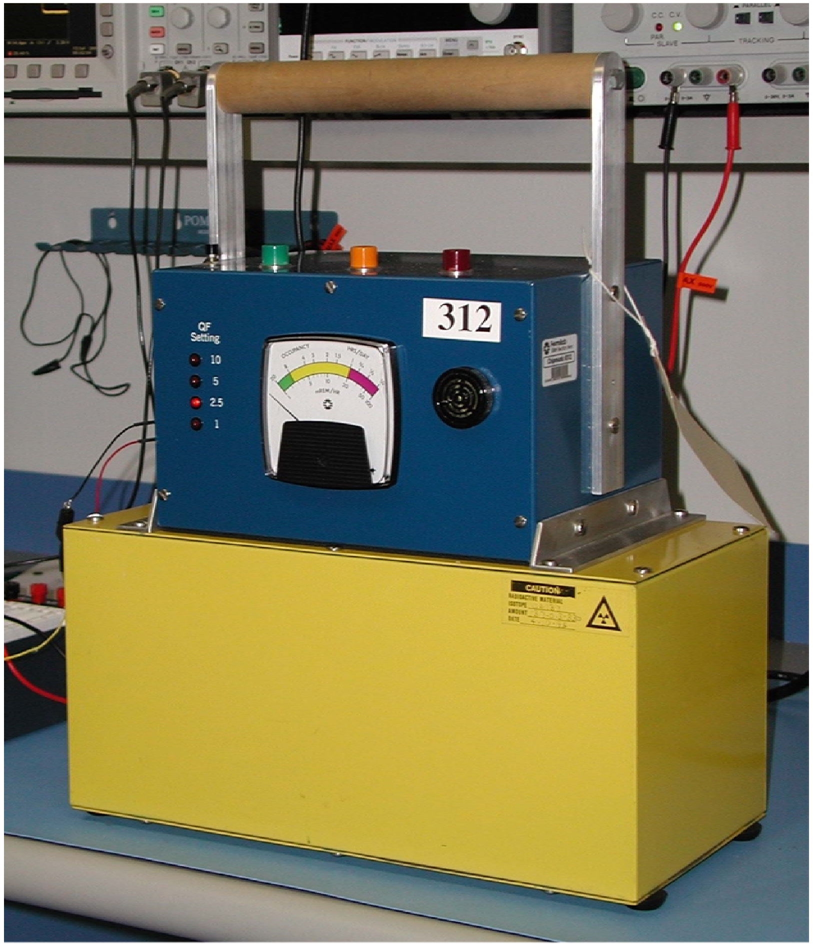
Warning Devices

- Beam shutdown stations located every 100 feet
- Tunnel lights dim prior to beam operation
- Public Address system in tunnels

Radiation Detection

- Based Fermi Lab style “Chipmunks”
- Units will be installed outside the shielding
- Units may be applied non-redundantly or redundantly depending on potential radiation levels
- Outputs will be used to shut off beam
- Pulse signals will be sent to the operator interface for display, trending and archiving

PPS Devices



PPS Phases

- Phase 0- Front End and DTL tank 1
  - Temporary system installed and operated from the front end control room
  - Allows installation of subsequent PPS equipment without disrupting commissioning
  - Provides access control for temporary DTL hut when commissioning DTL tank 1

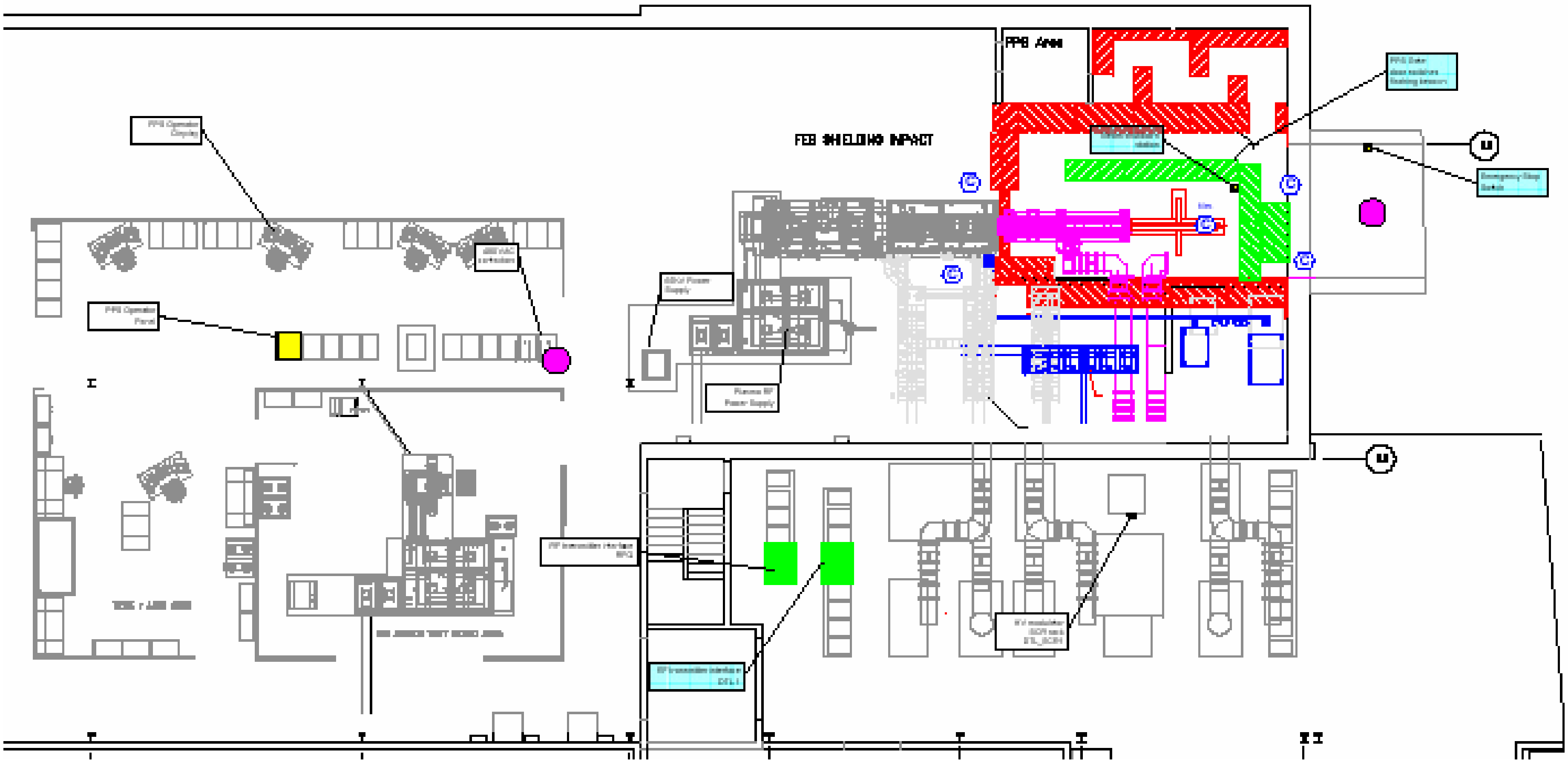
PPS Phases

- Phase 1- LINAC segment
  - Provides access control for the LINAC segment
  - Used throughout CCL commissioning
  - Requires temporary shield wall at the end of the CCL
  - Will be operated from the front end control room
- Phase 2- LINAC and HEBT segments
  - Provided to allow commissioning of the SRF LINAC to the LINAC beam dump
  - Operated from the front end control room or the CLO control room
  - Requires shield wall at the end of the HEBT

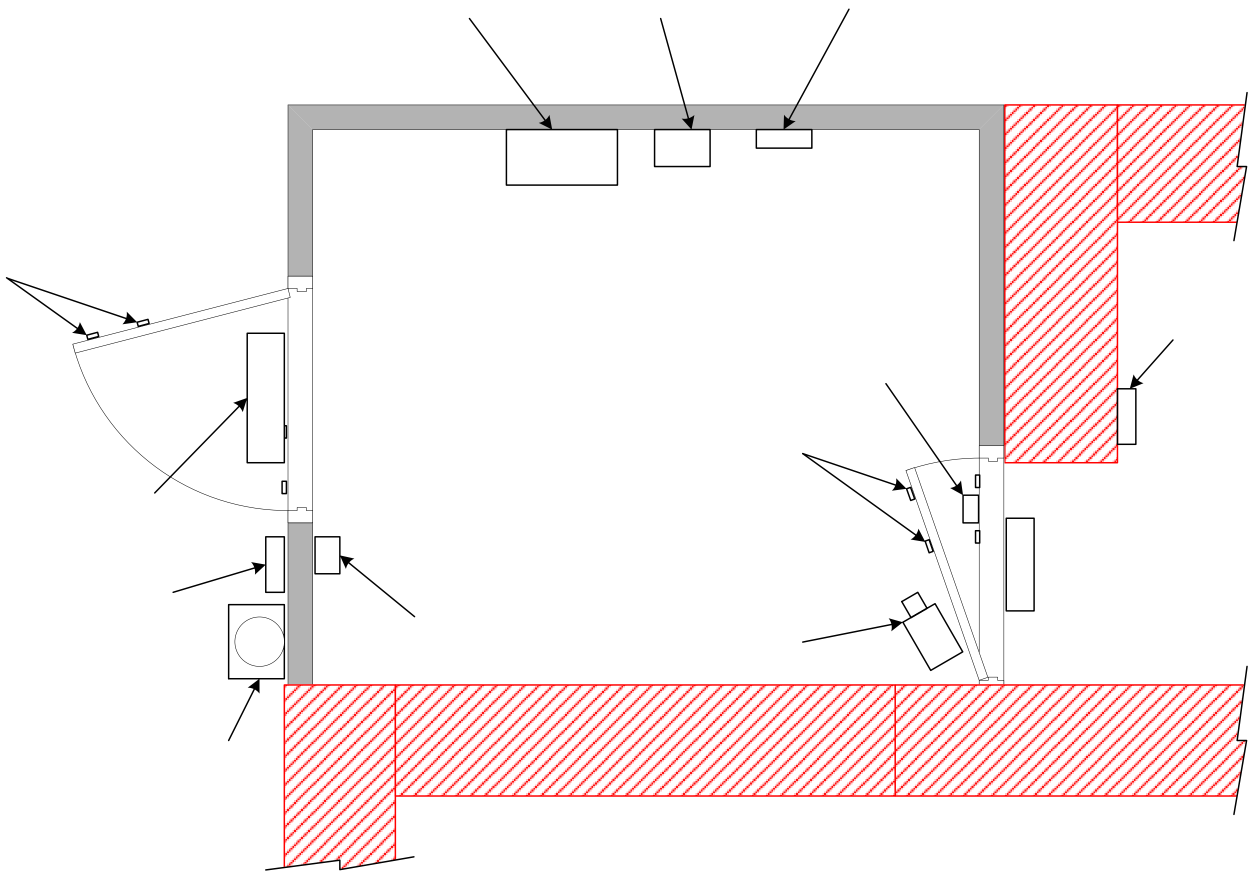
PPS Phases

- Phase 3- Accelerator
  - Includes all accelerator segments
  - Operated from CLO control room
- Phase 4- Entire facility
  - Includes target station & instruments

Phase 0



PPS Entry Station (Phase I)



RWP C
BADG

Exchange Keys

PPS Field Wiring Design Concepts

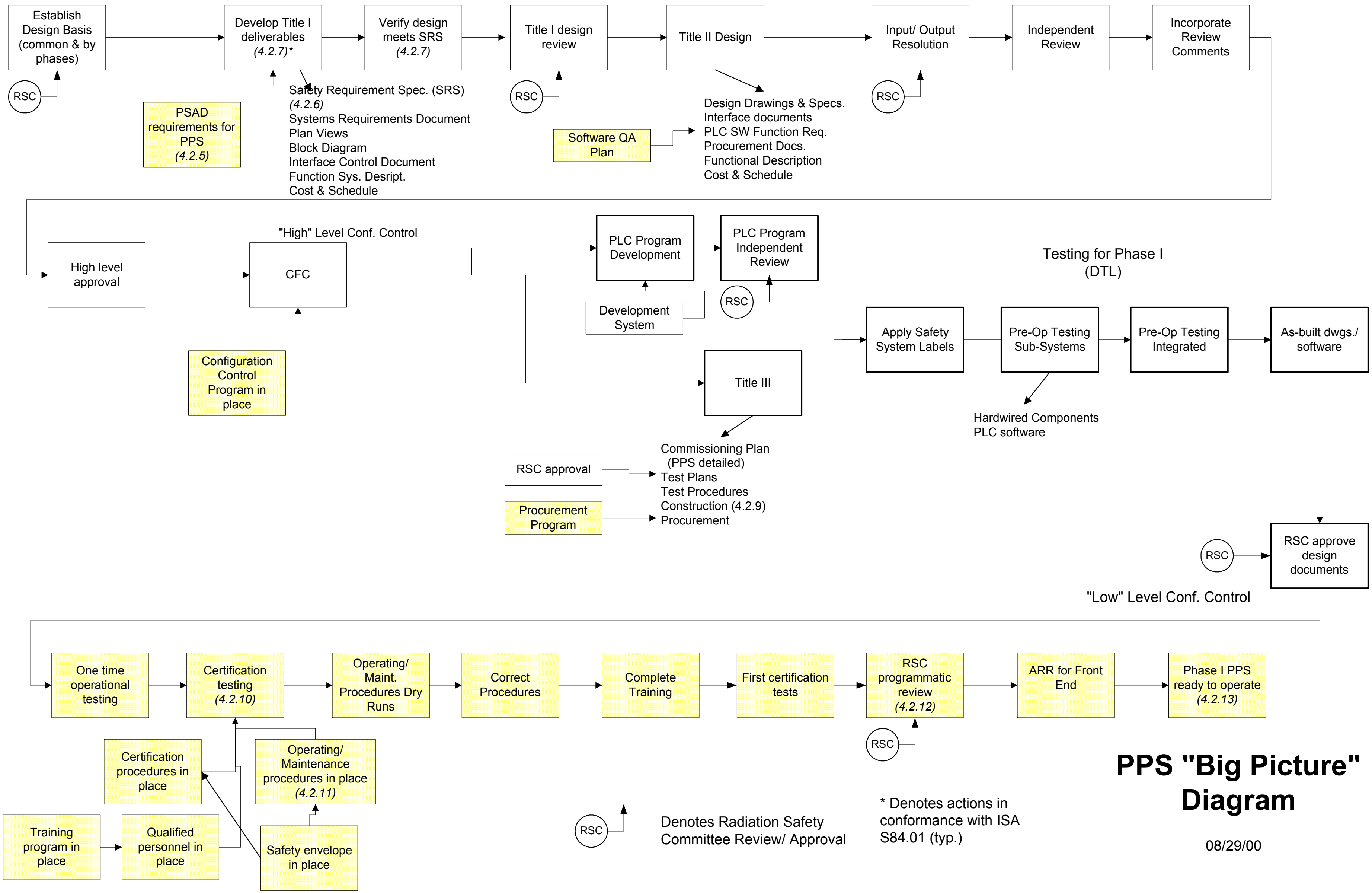
- Generally will use multi-conductor w/ overall shield (SNS standard 600 V tray cable)
- Run in separate PPS tray or conduit or in shared tray w/ divider
- Shared tray is shared with benign systems such as communications/ fire alarm etc.
- Conduit/ tray installed and cable pulled by DB contract electricians/ terminated and tested by PPS technicians
- Cable routing/ tray design by ASD Electrical group. Short runs of conduit by PPS group

MPS interface

- PPS will provide redundant inputs to MPS to indicate segment status (beam permit or not). One pair of inputs from each accelerator segment.
- MPS will provide redundant inputs to PPS to shut off beam (in phase 2). In the event the MPS unsuccessfully tries to shut down the beam, the MPS will provide a signal to the PPS that will have the PPS to shut down the beam.

Safety Life Cycle

- Analyze hazards
- Apply passive or administrative controls
- Determine active safety functions and performance levels
- Develop safety specifications
- Develop conceptual design and verify adherence to specifications
- Detailed design
- Installation, test and acceptance test
- Pre-startup safety review
- Operations, maintenance and periodic testing



PPS "Big Picture" Diagram

08/29/00

Hazard Analysis & Safety Functions

- Contains information on hazard analysis results
- Contains safety functions and safety integrity level requirements

Safety Requirements Specification

- Developed in accordance with ISA S84 requirements
- Contains basic system requirements
  - Requirements from hazard analysis
  - Safety Functions
    - Process inputs
    - Process outputs
    - Relation of inputs to outputs
    - Manual shutdown
    - Response time
    - HMI
    - Reset
  - Required SIL
  - Diagnostic requirements
  - Maintenance and testing requirements

Software Safety Requirements Specification

- General Requirements
  - Safety Functions
  - PLC specification
  - Network Architecture
  - Programmer restrictions
- Fault detection and response
  - PLC faults
  - Equipment faults (feedback)
- Inter-PLC I/O
- Inputs from field devices
  - Key switches
  - Position switches
- Program formats
- Operating Logic
  - Operating Modes
  - Personnel Entry Doors
  - Sweep Logic
  - Beam Permit Logic
- Logic is represented by a combination of flowcharts and Boolean logic diagrams

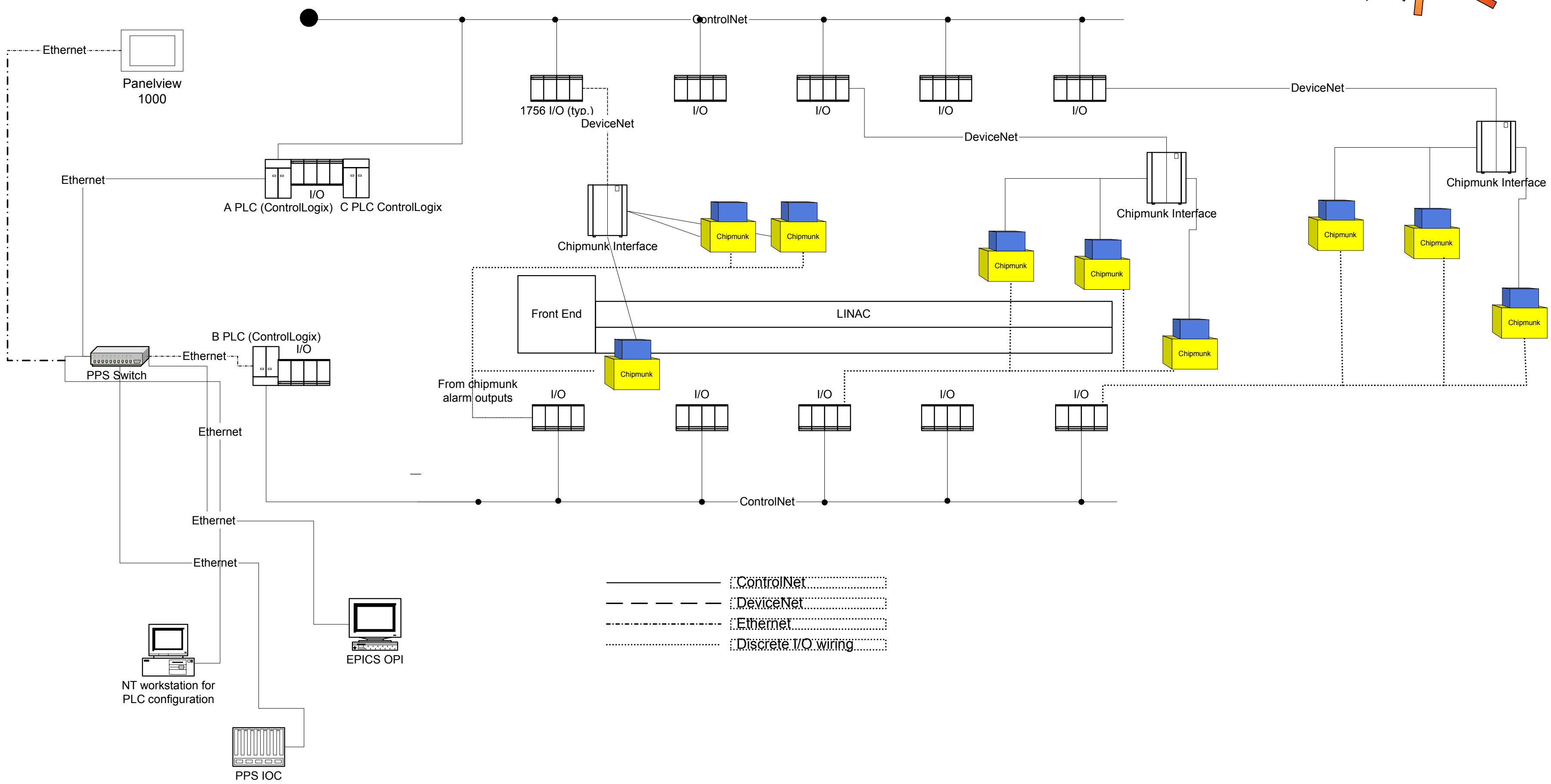
Programmable Logic Controllers

- Redundant programmable logic controllers (PLCs) for each segment
- Uses the SNS standard PLC
- Input and output circuits are designed to be fail safe (energized to enable, de-energize to disable)
- Signal and control cabling, along with the PLC network cable, will be routed in separate wireways from other cabling
- A common functional software requirements document will be prepared- the logic for each PLC is developed by separate engineers
- Production PLC programming is rigorously controlled in accordance with the software configuration control procedure

SNS Standard PLC

- Allen Bradley ControlLogix family of PLCs
- Pros
  - Up to date design with several networking options
    - ControlNet
    - EtherNet
    - DeviceNet
  - EPICS driver developed for SNS project
  - Broad usage at SNS provides many knowledgeable staff members to help with design/ programming issue
  - Product availability and support expected to continue for many years

Phase I PLC Networks



EPICS Security

- PLC communicates status to EPICS
- EPICS CIP driver modified such that EPICS cannot write to PLC
- VX operating system modified to prevent external log in
- Separate Ethernet port on IOC separates accelerator VLAN from PPS LAN
- Testing will be performed to demonstrate system integrity in the event of VLAN malfunction or hacking attempt

Radiation System PLC

- ControlLogix family allows multiple PLC processors in a chassis
- Separate PLC processor provided in A system chassis to process pulse inputs from Chipmunks
- Processor communicates with AB Panelview interface to allow radiation safety officers to enter Chipmunk data
  - Setpoints, serial number, location, quality factor, background pulse rate
- PLC summarizes Chipmunk status and provides single digital output to A PLC (does not communicate over backplane)